Joint Probability Distributions in MLife

MLife provides an option for a user-specified distribution by setting the UserDistrib flag to true in the settings file.

When UserDistrib equals true, the standard MLife-computed one-dimensional Wiebull wind speed distribution is not used.

If a user-specified table is used, you must specify the number of dimensions to the multi-dimensional distribution, `nDistribVars`.

The settings file includes a Distribution section that provides necessary information about the user-supplied distribution. This information includes: 1) the filename, 2) the number of variables included in the distribution.

For example,

```
-----  Distributions ------------------------------------------------------------
true            UserDistrib         User defined distribution?  true = load user-specified distribution, false = only use Weibull wind
distribution
2               WeibullShape        Weibull shape factor. [used only when UserDistrib = false]
10              WeibullScale        Weibull scale factor if WeibullShape<>2.  Otherwise, enter the mean wind speed. [used only when UserDistrib =
false]
3               WSin                Cut-in wind speed for the turbine normal operation.
21              WSout               Cut-out wind speed for the turbine normal operation.
31              WSmax               Maximum wind speed value for the wind-speed bins.
2               WSMaxBinSize        Maximum width of a wind-speed bin.
4               nDistribVars        Number of independent variables in the user-specified distribution, ignored if UserDistrib = false
"JointDistrib.dat" DistribName      Filename of the user-supplied distribution table, ignored if UserDistrib = false
```

Each input time-series, must specify the mean value for each variable (1 to `nDistribVars`) in the supplied distribution, so that an appropriate PDF value can be selected.

For each time-series, MLife will look-up a probability value from the user-supplied table, and apply this factor when weighting cycles for lifetime fatigue and DEL calculations.

For a distribution table with 4 independent variables, the file listing section of the settings file would look like this:

```
-----  Input Files  -------------------------------------------------------------
1                FileFormat        Format of input files.  1 = FAST ascii, 2 = FAST binary
3  1.1   1.3   1.5   1.7    (Weibull-Weighted Normal Operation: NumNormFiles, PSF1, PSF2, PSF3, PSF4)
"DLC1.1_01_small.out" 6.1 233.3 4.5 4.7  (Filename, time-series Mean of Var1, Mean of Var2, ... Mean of VarnDistrib)
"DLC1.1_07_small.out" 8.4 233.3 4.5 4.7
"DLC1.1_13_small.out" 6.1 233.3 8.5 4.7
3  1.1   1.3   1.5   1.7    (Weibull-Weighted Idling: NumIdleFiles, PSF1, PSF2, PSF3, PSF4)
"DLC1.1_19_small.out" 4.1  233.3 4.5 4.7
"DLC1.1_25_small.out" 8.1  233.3 4.5 4.7
"DLC1.1_31_small.out" 10.1 233.3 4.5 4.7
3  1.2   1.3   1.4   1.6    (Discrete Events: NumDiscFiles, PSF1, PSF2, PSF3, PSF4)
"DLC1.1_37_small.out"
"DLC1.1_43_small.out"
"DLC1.1_49_small.out"
```

The distribution table is stored in binary file format with the following specifications:

The binary format is little-endian, which is the standard format for Windows PC operating systems.

The distribution file begins with a header section and is followed by a data table.

1. The distribution header section consists of:
    a. A 2-byte integer designating the number of bytes used to represent the floating point table values [4 or 8]
    b. A 256 byte character string with the distribution name
    c. 2-byte integer designating the number of variables for this distribution
    d. For each distribution variable, there are the following data:
        i. 2-byte integer designating the number of bins for this distribution variable
        ii. A 4-byte single-precision real designating the smallest value of the distribution variable. (left edge of the first bin)
        iii. A 4-byte single-precision real designating the bin width of the distribution variable

2. The table section contains a multi-dimensional matrix of reals (number of bytes per entry specified in 1a) containing the probability density function. This table has the following properties:
    a. The number of dimensions of the matrix equals nDistribVars. The size of each dimension is equal to the number of bins for each table variable.
    b. Every entry should have a value greater than or equal to zero and less than or equal to one.
    The sum of all values should be 1 (if the full distribution is represented), or less than 1 if part of the distribution is not represented in the table.